

Bulletin 125.

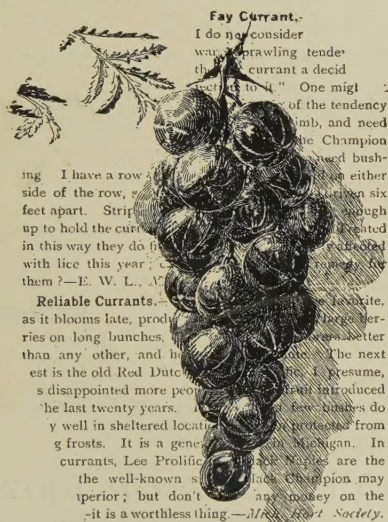
February, 1897.

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

A Disease of Currant Canes.



Fay Currant.

I do not consider
was a crawling tender
that the currant a decid
One might
of the tendency
bush, and need
the Champion
bush-
ing I have a row
side of the row, six
feet apart. Strips
up to hold the cur-
in this way they do
with lice this year
them?—E. W. L., A.

Reliable Currants.—The variety, as it blooms late, produces large berries on long bunches, and is a better than any other, and is the next best is the old Red Dutch. I presume, is disappointed more people than introduced the last twenty years. A few growers do very well in sheltered locations, protected from frosts. It is a general favorite in Michigan. In currants, Lee Prolific and Lee's are the well-known sorts. The Champion may be superior; but don't lay money on the—it is a worthless thing.—*Agricultural Society.*

By E. J. DURAND.



PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1897.

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The regular bulletins of the Station are sent free to all who request them.

BULLETINS OF 1897.

124. The Pistol-Case-Bearer in Western New York.
125. A Disease of Currant Canes.

CORNELL UNIVERSITY, Ithaca, N. Y., Feb. 1, 1897.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following account of a currant disease, of which almost nothing has heretofore been known, is submitted as a bulletin under provision of Chapter 437 of the laws of 1896. This cane-blight is probably more widespread and serious than anyone has suspected, and it would not surprise us if it should be found that much of the trouble with currants which is laid to hard winters and poor soil is really the result of the work of this fungus.

L. H. BAILEY.

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III. Remedies, - - - - -	38



2. *Diseased currant plant, showing dead canes and shriveled fruit.*

A DISEASE OF CURRANT CANES.

I. GENERAL CHARACTER OF THE DISEASE.



3. *Diseased currant canes, natural size* (a, *Tubercles of Tubercularia*; b, *clusters of perithecia of Nectria*; c, *clusters of perithecia of Pleonectria*).

During the last few years there has existed, in various portions of New York state, a disease of currant bushes, which has been more or less destructive to the currant industry. The trouble was first called to the attention of the Experiment Station staff in June, 1895, when a diseased bush was received at the Botanical Department from Portland, Chautauqua county. Outside of this locality its effects have since been observed by the present writer at Canandaigua, Ontario county, and in the gardens of the Horticultural Department of Cornell University, in Tompkins county. It has also been noticed by Professor G. F.

Atkinson in St. Lawrence county. Outside of New York state it has been reported from New Jersey by Dr. B. D. Halsted.

Inasmuch as the disease seemed to be a destructive one its study was thought to be of interest and importance. It was de-

terminated, therefore, that the writer should visit the locality of the trouble in Chautauqua county to observe its effects upon the currant bushes, and to obtain material for study. Accordingly, on the 26th of June, 1895, the fruit-farm of Mr. I. A. Wilcox was visited, and notes taken upon the disease as it appears in the field.

Effects of the Disease.

The currant plot was found to be about one acre in extent. It originally consisted of several acres, but the death of the plants reduced it to the present size. About two-thirds of the bushes in the area at the time of the visit were either dead or manifestly diseased. The plants which had died the previous year were replaced in the spring of 1895 by new plants, which at this time were apparently unaffected.

The first effects of acute disease in the plant are seen in the wilting of the foliage, and the premature coloration of the fruits. The leaves turn yellow, dry up and fall away. The fruit clusters on affected plants are usually much smaller and more thinly fruited than on healthy ones, while the berries are colored prematurely, shrivel and fall away with the leaves, so that the canes are barren (Fig. 2.) The latter then die rapidly and soon dry up. Frequently the central canes of the bush die in the manner described, while the outer ones still retain their leaves. In nearly all such instances, however, the leaves of the living parts show indications of disease. Sometimes the plants die before the leaves unfold, so that the unopened flower and leaf buds may be seen upon the dead branches. In the worst cases, where all the canes are dead, the roots also die. Occasional instances were noted where fresh sprouts had been sent up around the base of the diseased canes.

Cuttings made from apparently healthy bushes in this plot were unusually slow in growth, many of them not starting at all. Those which did start were very backward and amounted to but little. Two-year-old plants were also backward and slow in growth. The action of the cuttings suggests that the mycelium of the disease may be perennial in the tissues of the host plant, or, at least, that the vitality of the branch may be impaired before the effects of the disease begin to be noticeable.

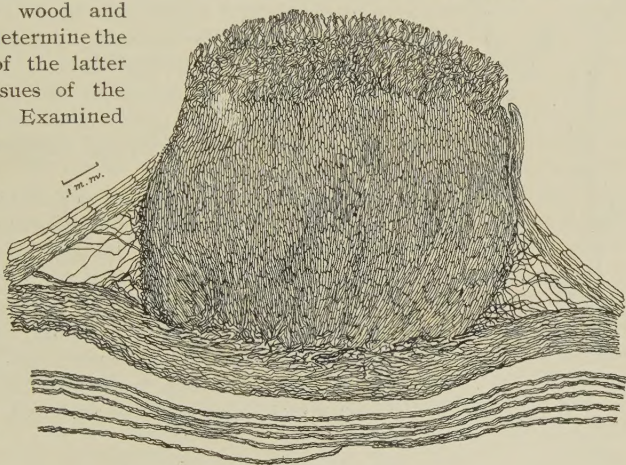
II. THE BOTANICAL CHARACTER OF THE DISEASE.

The Fungus.

On a great majority of the dead canes the pink tubercles of a fungus of the genus *Tubercularia* were present (Fig. 3, a). They occurred most abundantly near the base of the stalk, but occasionally were found high up on the stem. Very few bushes were seen which had no tubercles on any of the canes. Sometimes they were present on much diseased stems not completely dead. In no case were they present on healthy plants. The tubercles were sufficiently abundant and so distributed on the diseased and dead stems as to render it probable that the fungus produced the disease and caused the death of the plants. A careful search was made for perithecial forms, but they were found on only a single plant. These with several specimens of the *Tubercularia* were collected for study.

An examination showed the tubercles to be the fruiting bodies of a well known species, *Tubercularia vulgaris*, Tode. Careful sections were made through the wood and tubercles to determine the connection of the latter with the tissues of the host (Fig. 4). Examined

under the microscope, one of these sections shows that the vegetative part of the fungus consists of a delicate thread-like mycelium spreading abundantly through the



4. Longitudinal section of a tubercle of *Tubercularia*.

tissues of the currant stem. The depredations are confined to the younger tissues of the host, within which it forms a wide web between the cells. It thrives well in the inner bark or cambium layer, thus cutting off the nutriment and causing the death of the plant. The cells affected by the mycelium are much disintegrated and turn brown.

The hidden mass of mycelium coursing through the tissues is the part that is destructive to the currant plant, since this is the only portion of the fungus that absorbs nutriment. The pink tubercles are the fruiting organs of the fungus. In their formation numerous threads of the mycelium turn outward from the bark as a bundle of closely compacted parallel filaments. As

growth progresses outward the mass breaks through the epidermis of the host, and appears as a pink cushion on the surface of the stem. A longitudinal section through one of these when examined under the microscope presents the appearance represented in the figure. The long, spreading mycelial threads may be seen coursing through the layers of the bark forcing the cells apart. In the tubercle itself the threads are broader and much septate by cross partitions, so that the mass thus formed resembles a tissue composed of narrow elongated cells. Toward the top of the tubercle the filaments are more compacted and thread-like. At the surface they become separated from one another and sparingly branched, each bearing small spores or conidia at its apex, and on very short branches or stigmata along its



5. *Hyphae of Tubercularia bearing conidia.*

sides (Fig. 5). These conidia are exceedingly small measuring only 6-8 μ long by 3 μ wide. They are narrowly elliptical in outline and colorless. Immense numbers of conidia are borne on each tubercle, and, being so small and easily detached, are scattered widely by the wind, thus forming a very efficient means of spreading the disease. Each conidium is capable of germinating under favorable conditions of temperature and moisture. The slender tube thus produced enters the tissues of the host, where it elongates and branches producing an abundant mycelium.

The perithecia found on one of the canes were not fully mature, but were sufficiently so to admit of the determination of the species as *Pleonectria berolinensis*, Saccardo. This was afterward found to be a separate fungus in no way connected with the *Tubercularia*. All of the canes collected on the trip were planted in the leaves and humus in one of the nearby ravines, in the hope that more of the perithecial forms would be produced.

The History of the Fungus.

The *Tubercularia vulgaris* is a very common fungus which has long been known as a saprophyte growing on dead and decaying branches. Nearly all of the deciduous woody plants are numbered among its hosts, the genus *Ribes*, to which the currant belongs, being a favorite in this respect. It has passed under many names according as the forms on the various hosts were regarded as belonging to the same or distinct species. In 1865, Tulasne (*Selecta Carp. Fungorum*, III), united all these forms under the old name *Tubercularia vulgaris*, Tode, and gave numerous drawings and facts to prove its connection as an imperfect stage with the very common ascomycetous species, *Nectria cinnabarina*, (Tode) Fr. That this connection exists is evident, so that the fact has since stood unquestioned. In regard to the

special relation existing between these fungi and the currant, Dr. M. C. Cooke wrote for the Gardiner's Chronicle of Feb. 28, 1871, a short paper entitled "A Currant Twig and Something on it." Here were described in a popular way the pink cushions of *Tubercularia*, the mycelium, and the connection of this form with the globular, compound heads of the perfect stage *Nectria cinnabarina*. The plant described in this paper was found on a dead currant branch pulled out of a brush pile.

Its Occurrence as a Parasite.

Most of the writers treating of *Nectria cinnabarina* have spoken of it in a general way, as a saprophyte growing on dead or decaying woody plants. It has long been known, however, that both the *Tubercularia* and *Nectria* may thrive upon living plants in a truly parasitic manner. In Germany this condition seems to be not uncommon. As early as 1880, Dr. H. Mayr¹ studied the fungus as it occurred on living horsechestnut, maple (*Acer platanoides*), and linden, besides noting it upon elm, *Spiræa* and *Prunus*. In the case of the maple the spores germinated upon the cut end of a branch of a young tree, sometime during the year 1880. The mycelium spread to the main stem killing a portion of it. Here the first tubercles appeared, probably in the fall of the same year. During 1881, the new wood was seized upon and killed, so that in the autumn of the same year the leaves withered and died. At this time perithecia appeared on the tubercles of the previous fall. The same writer also studied the development of the fungus, describing and figuring the germination of the spores, and the conidial and perithecial forms. In 1893 and 1894, Wehmer studied some peculiar developments of *Nectria cinnabarina* on linden,² *Carpinus*,³ and *Juglans regia*.³ J. Behrens,⁴ also, found the fungus parasitic on *Abies balsamea*. In the summer of 1896, Mr. B. M. Duggar, of the staff of this Station found the same fungus growing in a truly parasitic manner on a pear tree at Fayetteville, Onondaga County, N. Y.

The first mention of *Nectria* as a parasite of currants seems to be that of Dr. Halsted, who speaks of it as follows :⁵ "In the currant regions of the state, particularly around Hilton and Irvington, there has been complaint of a blight affecting the canes of the currant. . . . An affected plant may often be detected by the wilted foliage and premature coloration of the fruit. In some instances only a single cane in the bush may be attacked, while in the worst specimens the whole shrub is dead, except the fresh sprouts which may have arisen from the base of the plant. In early

¹ Ueber den Parasitismus von *Nectria cinnabarina*. Unters. a. d. forst-botanischen Institut zu München 3 : 1-16, 1883.

² Zum Parasitismus von *Nectria cinnabarina*. Zeitschrift f. Pflanzenkrankheiten. 1894 : 74.

³ Einige weitere Beiträge zum Parasitismus von *Nect. cinnabarina*. Id. 1895 : 268-276. Pl. V.

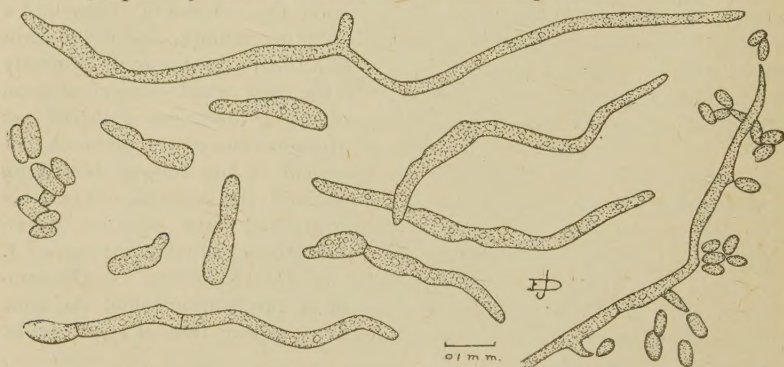
⁴ Ein bemerk. Vorkommen v. *Nectria cinnabarina*, und verbreit weiss. d. Pilze. Id. 1895 : 193-198.

⁵ New Jersey Ag. Exp. Station, Report for 1894, : 327.

July the blighted twigs often have their bark ruptured, and through the rifts there is to be seen a somewhat brick-colored fungus growth. Upon examination with the compound microscope, this red development is found to be the spore-bearing organs of a highly organized fungus belonging to the genus *Nectria*. This genus is not an unusual one among the fungi that are harmful to higher plants. . . The one upon the currant, when it seems to be deeply seated and does much damage, is nearly related to the *Nectria cinnabaria*, Tode, which is common on various trees." The effects of the disease in New Jersey are thus seen to be nearly identical with those observed in Chautauqua County.

Cultivation of the Tubercularia.

On November 16th, 1896, another package of diseased currants was received from Mr. Wilcox. The canes were badly affected, being thickly studded, especially about the lower ends, with the pink cushions of *Tuber-*



6. Germinating conidia of *Tubercularia*. Portion of mycelium producing secondary conidia.

cularia. The stems were covered and allowed to stand for a day in a moist place, so that the cushions were well moistened and swollen out. In order to avoid contamination as much as possible the spore-bearing tops of several of these cushions, after being shaved off with a sterilized scalpel, were crushed in boiled water on a flamed glass slip. Vast numbers of conidia were present. Dilution cultures of these were then made in acidified potato-agar in the usual manner. This was done in order that the germination of the conidia, and the development of the mycelium in artificial culture media might be studied. After twenty hours the spores had begun to germinate freely. The various stages of germination are illustrated in Figure 6. In this process the spore first swells to more than twice its original size through the absorption of moisture. A small protrusion then appears at one or each end of the conidium, which grows in length as a germ-tube. These tubes are quite large in proportion to the size of the spore, so that as growth pro-

gresses the original spore is soon lost sight of. In most cases the germ-tubes are soon cut off by septa. The protoplasm is at first nearly homogeneous, but soon becomes vacuolate in the older portions of the tube. After having elongated considerably the thread becomes sparingly septate by the formation of cross partitions. In old cultures the older parts of the mycelium are much septate and filled with vacuoles. The threads soon begin to branch, until finally a spreading mass of densely interwoven mycelium is produced.

In threads thirty-six hours old, numerous small, short protrusions appear along the sides of the threads near the ends. These at first resemble incipient branches, but are usually of considerably less caliber than the main threads. They are as often curved as straight. When the bud is a little longer than the diameter of the main thread, a constriction appears near its base, so that the apical portion soon separates as a secondary conidium (Fig. 6). The base then grows out, so that other conidia are thrown off from the same point in a similar manner, until small clusters are present along the sides and apex of the main hypha. In old cultures these secondary conidia are present in immense numbers. As represented in the figures, the primary and secondary conidia are borne in precisely the same way along the sides and at the apices of hyphal threads. Being alike also, in size and shape, they differ only in that the primary conidia are produced on more or less erect hyphae, arising from the summits of the compact pink cushions formed by the coalescence of hyphal threads. The secondary conidia, on the other hand, are borne on separate hyphae, arising directly from the spores, and thus not forming a compact stroma. Morphologically, however, the two fruit forms are exactly alike.

Many cultures of the conidia of *Tubercularia* have been made, in all of which the mode of germination and production of secondary conidia were as described in the preceding paragraphs. Many of the cultures made from fresh material were more or less contaminated by the presence of bacteria or other fungi. In one set, however, plates two and three were pure, being thickly beset with numerous colonies of the *Tubercularia* alone. From plate three of this series transfers were made with a flamed needle to tubes of sterilized bean stems and potato-agar. At this time the colonies were about four days old, and secondary conidia were present in great numbers. Pieces of agar containing colonies were also transferred to sterilized currant stems in an Ehrlenmeyer flask.

On the potato-agar growth was rapid and profuse. The surface of the medium was soon covered with a felty growth, many of the hyaline threads extending far down into the mass. On the bean stems, also, the growth was rapid. The surface of the liquid was covered with a hyaline, felty growth, from which many of the threads projected downward as in the agar. The growth on the stems was sparse consisting of a thin web of hyphae covering the substratum, and forming white flocculent tufts at the ends of the stems. After eleven days growth numerous small, hemispherical heaps or cushions began to appear on the bean stems at various points. These, at first, were

simply little tufts of threads about the size of a pin-head, but later they increased to several times that size. They were then pure white, somewhat compacted, and cottony in appearance. When examined under the microscope, these cushions were found to consist of erect parallel hyphae, much like fertile threads, but no conidia have yet been detected upon them.

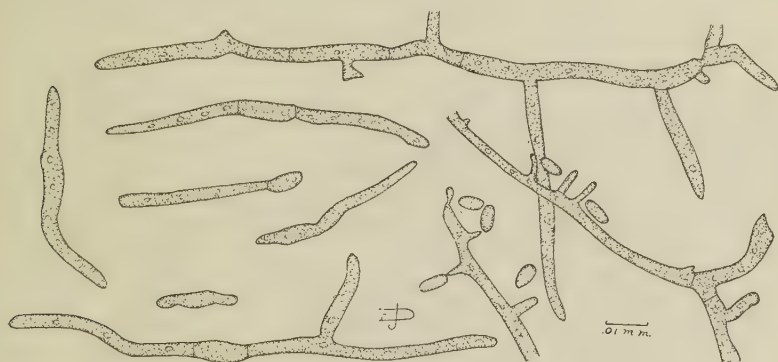
On the currant stems in the Ehrlenmyer flask growth was at first slow. In a few days, however, a long sparse growth of mycelium could be seen spreading thinly over the surface of the stems. In a short time the mycelium became somewhat flocculent in spots, especially at the cut places where branches had been removed from the stems. After fourteen days growth, the white cushions began to be formed, especially at the cut surfaces mentioned. In appearance these were exactly like the ones described on the bean stems. When old they became yellowish, and closely compacted into a stroma, which was slightly pinkish within. Several instances have been noted in which a swelling or protrusion appeared at the summit or side of one of the white cushions, and which seemed at first to present every indication of a forming perithecium. It was soon found, however, that the protrusion was simply a true, pink stroma of *Tubercularia*, resembling in nearly every respect those found in nature. Conidia were present in great numbers at the summit of the mass. In the flask, also, on the felty mass covering the surface of the currant leaves and liquid at the bottom, small pink tubercles have arisen, which in many respects resemble those found on the currant stems in nature.

It may be mentioned at this point, that in none of the artificial cultures has there appeared any indication of the fruit-bodies described by Mayr⁶ as macroconidia. These were said to be long, fusoid, several-septate bodies, borne on tufts of white mycelium, at points where the stromata of *Tubercularia* later appeared. The macroconidia after germination produced secondary macroconidia of a similar form, by budding-off from the mycelium. It was thought at first, that the white cushions mentioned in the last paragraph might represent these macroconidial stromata, but a careful search has failed to reveal any fruiting-bodies of such a form. The fact that no such bodies appeared in the carefully made pure cultures, together with their very marked similarity to the conidia of a very common saprophytic fungus of the genus *Fusarium* has raised the suspicion that perhaps the macroconidia may have belonged to another fungus not connected with *Tubercularia*.

In order to determine the function of the secondary conidia thrown off from the mycelium growing in agar, dilution cultures were made, that they might be obtained in pure cultures. This was done by transferring a portion of a *Tubercularia* colony, containing numerous secondary conidia, to three agar tubes successively and pouring into plates in the ordinary manner. Plate number one was then examined under the microscope, and the position of the conidia marked on the glass. After twenty-two hours these

⁶Untersuch. a. d. forst-botan. Inst. zur München. 3 : 1-16, Pl. I, figs. 18-21.

marked spores were found to have germinated in a manner similar to that described for the primary conidia taken from the pink tubercles. The spores first swelled to several times their former size, when germ-tubes were pushed out from the sides and ends (Fig. 7). The protoplasm was granular and filled with vacuoles. Septa appeared early, cutting off the tubes at their points of origin. After forty-eight hours growth, the mycelium was found to be much branched, quite dense, and not widely spreading. The main hyphae had put out short branches quite simultaneously along their sides, so that the lateral branches were of nearly equal length. After fifty-six hours these branches were throwing off secondary conidia precisely as the mycelium from the primary conidia had done (Figs. 6 and 7). It will be seen, therefore, that the primary and secondary conidia behave almost exactly



7. *Germinating secondary conidia of Tubercularia.*

alike in their germination, and in their production of fruiting bodies. This is no more than might be expected when we remember that the two forms are morphologically similar.

The behavior of these colonies varied much with the food supply. In plate number one, after the nutriment had become nearly exhausted on account of the large number of colonies present, the mycelial threads became very profusely and compactly branched, forming close colonies. The protoplasm became full of very large vacuoles. In plates number two and three, where the nutriment was more abundant, the threads were much longer, more slender, and less branched, thus forming a more spreading colony. The protoplasm was nearly homogeneous with few vacuoles.

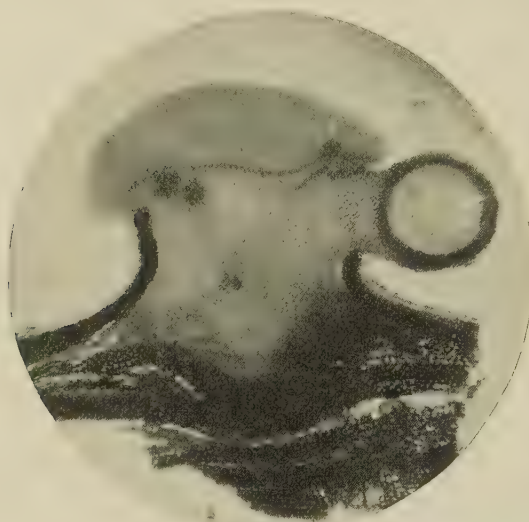
On March 14, 1896, colonies produced from secondary conidia were innoculated on sterilized currant stems, neutral bean stems and acid bean stems. Here again the growth was similar to that described for the primary conidia. The mycelium grew slowly, but after three days, formed a thin web over the stems. After four or five days the small white cushions began to form and increase in size, in nearly every respect resembling those previously described.

The various cultures and inoculations detailed in the preceding paragraphs were made in the hope that it would be possible, finally, to trace in artificial cultures the exact relation and connection existing between the *Tubercularia*, and the perithecial forms of *Nectria* and *Pleonectria*. It may be said, however, that at the time of the present writing, after a lapse in some cases of many months, nothing but the stromata of *Tubercularia* has appeared in the cultures. In explanation one might cite Mayr's observations on the maple (see p. 27). In this case the perithecia did not appear until a full year after the stromata had been formed. It is known, too, that many forms require a much longer time than this to attain to their complete development under artificial conditions. The methods of culture may not have been

favorable to the production of the perfect form. It is known that many species require a period of rest before such forms will be developed. That a connection exists between *Tubercularia vulgaris* and *Nectria cinnabarina* has been abundantly demonstrated, so that the fact is no longer open to question (Mayr, l. c.)

Nectria cinnabarina.

All of the perithecia developed during the fall of 1895, on the currant bushes planted in Fall Creek Ravine, were those of *Pleone-*



9. Longitudinal section of a stroma and single perithecium of *Nectria*.

ectria, which is not connected with *Tubercularia* as is shown in a succeeding paragraph.

The canes were examined at intervals during the fall and winter of 1895-96, but it was not until February that a branch was noted, on which clusters were present, which differed decidedly in appearance from those previously observed on this material (Fig. 3, b.) The perithecia were a light brick-red in color, were small, spherical, and densely crowded, and covered with little granules, giving them a rough appearance. There was no depression at the apex as in *Pleonectria*. The clusters were seated on prominent stromata, evidently those of *Tubercularia* (Fig. 3, b and 9.) The tubercles and perithecial clusters were intermingled freely. Many tubercles

were present, from the bases and sides of which the perithecia were projecting. All gradations could be seen, from the simple tubercles covered with conidia, through those bearing one or several perithecia, to those entirely covered by clusters. Conidia were present on all of these stromata.

A microscopical examination showed, as was suspected, that the fungus in question was none other than *Nectria cinnabarina* (Tode) Fr. If a perithecium be split longitudinally an appearance represented in Figure 9 is produced. It consists of an outer shell composed of coalesced threads. Springing from the bottom of this are numerous club-shaped sacks or *asci* which converge toward the apex of the perithecium. Each ascus contains eight elliptical spores which are divided into two cells by a cross-wall near the middle. They measure $12-15 \times 5-7 \mu$.



10. *Germinating spores of Nectria*

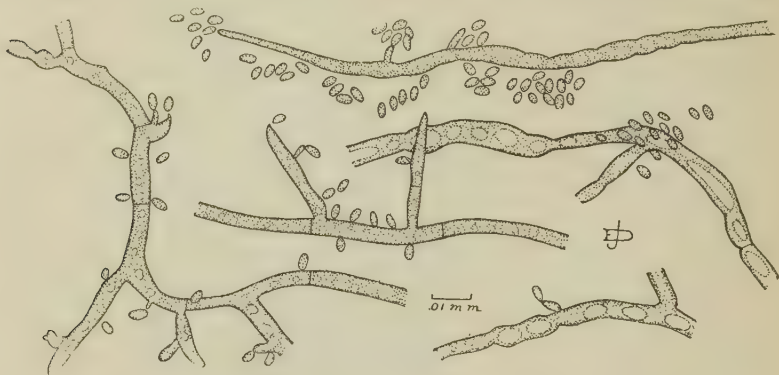
Cultures of the mature spores were made in acidified potato agar. The upper part of a cluster of perithecia was cut off with a flamed knife, the contents crushed out in boiled water, and dilutions made in the ordinary way. The plates were kept at the room temperature, 70 to 80°F. The spores swelled and germinated after twenty-two hours. In nearly every instance both cells of the spore germinated, each sending out one or two germ-tubes (Fig. 10). The tube more often originates at the end of the spore than at the side. There is often a more or less prominent constriction of the germ-tube at the point where it leaves the spore.

At this time no septa were present, the protoplasm of the tube being continuous with that of the spore, and faintly vacuolate. After twenty-eight hours branching had begun and a few septa formed. From this time growth advanced rapidly until the threads had branched into a spreading myce-

lium. After three days, the protoplasm became full of vacuoles placed at regular intervals. At this time conidia began to be thrown off from short lateral branches in a manner similar to that previously described. They were 4–5 μ long, or about the size of those of *Tubercularia* (Fig. 11).

When the cultures were four days old small portions of the agar containing colonies were transferred to sterilized currant and bean stems. The mycelium spread from the point of inoculation until a sparse cottony growth appeared over the stems, especially at the cut ends. Development was more vigorous on the currant than on the bean stems. After nine days growth minute white cushions began to be formed on the surface of the stems. These increased in size, and resembled in every way those previously described for *Tubercularia*. No perithecia have yet been produced in artificial cultures.

Cultures were also made of the conidia produced on stromata from which perithecia were borne. The germination, mycelial growth, and white cush-



11. *Mycelium of Nectria producing secondary conidia.*

ions produced resembled exactly the like phenomena in the case of *Tubercularia*.

Pleonectria berolinensis.

Reference has already been made on a previous page to the perithecia of *Pleonectria berolinensis*, Sacc. found on one of the currant canes brought from Chautauqua county. This species has long been known as an inhabitant of dead currant stems both in Europe and America. In North America it is said to occur on dead stems of *Ribes*, in Canada and the Northern United States, west to Montana.

No reference to this fungus as a parasite has been found. At the time the specimen was collected it was thought that perhaps the species might be another perfect form connected with the *Tubercularia*. The evidence, however, is against this view.

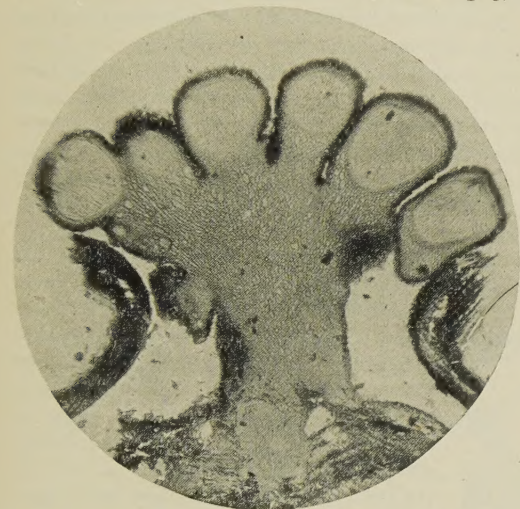
The currant bushes which had been placed in the ravine, as described on page 26, were left undisturbed during the summer and fall of 1895. About September first, perithecia began to appear abundantly near the bases of the

stems. By October first, many of the branches had produced large numbers of the fruit-bodies with mature spores (Fig. 3, *c.*). These resembled in

nearly every detail the specimens of *Pleonectria berolinensis*, Sacc. in Ellis and Everhart's North American Fungi, No. 470.

The perithecia are minute, smooth, spherical or pear-shaped bodies, and are usually borne in clusters closely crowded together. The color is brick-red or reddish-brown, bright when the plants are fresh, but duller when dry. Each cluster is usually seated upon a more or less distinct stroma, but seldom, if ever, is this a cushion of *Tubercularia*.

Most of the specimens examined seem to be nearly sessile upon the wood, but an evident stroma is shown in Fig. 13. The clusters originate beneath the bark, but as they grow older and larger, they break through and appear on the surface, bordered by the ruptured edge of the epidermis. Occasionally, several clusters are joined side by side, forming a ring extending nearly around the stem. In some instances, when the bark had been torn away, the perithecia are not clustered, but entirely distinct and superficial on the wood. In such cases there is no evidence of an underlying stroma, certainly none of *Tubercularia*. When fresh the perithecia are swollen out and nearly spherical; but when old and dry, the apical



13. Longitudinal section of a cluster of perithecia of *Pleonectria*.

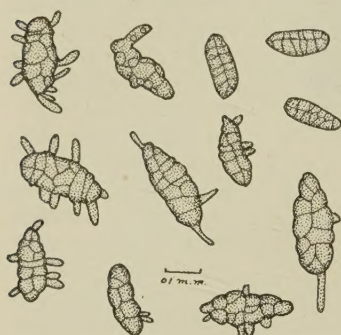


14. Longitudinal section of a single perithecium of *Pleonectria*.

portion around the minute opening collapses, so that a distinct and characteristic saucer-shaped depression is produced in each.

When the interior of the perithecium is examined a condition represented in Figure 14 is found. Around the outside is a wall or shell of sterile tissue, formed by the coalescence of hyphal threads. Projecting from the bottom of this wall, and converging toward the apex, are numerous cylindrical or club-shaped sacks, the *asci*, each containing eight elliptical, colorless spores. Each spore is divided by from five to seven cross-walls into sections, many of which are further divided by walls running across the first, as represented in Figure 15. The spores measure $16-22 \times 7-8 \mu$. The remaining interior part of the perithecium is filled with sterile tissue.

The spores are capable of germinating under favorable conditions and reproducing the species. Numerous cultures of the ascospores were made



15. Germinating spores of *Pleonectria*.

during the fall of 1895. Growth takes place freely in both acid and neutral potato-agar. A typical culture was started December 6th. At three in the afternoon, a dilution of three plates was made in acidified potato-agar, and kept in a room where the temperature was $70-80^{\circ}$ F. On Dec. 7th, after twenty-one hours, germination had begun.

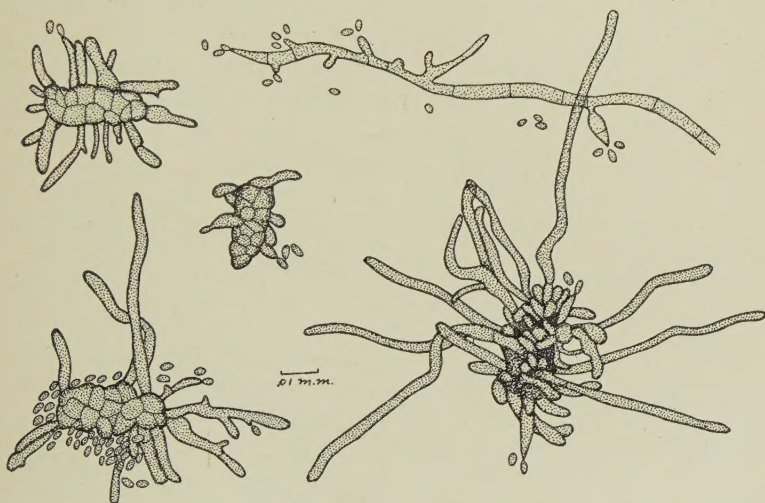
The spore first swells to several times its former size through the absorption of moisture. Small protrusions then appear at various points, which elongate more or less as germ-tubes (Fig. 15). In many cases the threads, after elongating a little, begin to throw off conidia by constriction

from their apices (Fig. 16). Such threads grow no further, but continue to cast off conidia in numbers. The conidia are oval in form, $4-6 \mu$ long, and closely resemble those of *Tubercularia*, except that they are a little smaller. The other germ-tubes elongate much by apical growth, and become much branched, forming a compact mycelium. Branching begins quite early, but septa do not become numerous until the thread has attained a considerable length. No definite relation could be seen between the number of germ-tubes and the number of cells of the spore. It occasionally happened that two or three tubes came from one cell, while some cells put out none.

After the mycelium was three days old, conidia in great numbers were cast off from the sides of the threads, much as in the case of the *Tubercularia* (Fig. 16). Short lateral branches are put out, which become constricted when as long as the diameter of the thread, and the apical portion is thrown off as an elliptical conidium. This process may be continued indefinitely by the same branch. The form of the lateral branches varies, some being long and tapering, while others are short and conical.

Innocations were made from the plate cultures to sterilized bean stems by

touching a flamed needle into a colony containing many conidia, and touching again to the stems. The only resulting growth, at first, was a thin, sparse mycelium, which was scarcely noticeable. No white cushions were produced. After about two weeks growth, in two of the cultures, minute red points appeared. When these had increased to the size of a pin-head minute red protrusions were pushed out from the summits of several of them. When examined under the microscope, each red point was found to be a stroma composed of compact hyphae, but bearing no conidia. The protrusions presented every appearance of being forming perithecia. Unfortunately, the cultures were spoiled at this time, so that the resulting growth could not be traced.



16. Mycelium of *Pleonectria* producing secondary conidia.

Mycelium of *Pleonectria* was also innoculated to bean stems on which cultures of *Tubercularia* were growing, but the growth seemed to be in no way modified thereby.

Innoculations.

On May 4th, 1896, a series of innoculations of *Nectria*, *Pleonectria* and *Tubercularia* was made on currant cuttings. These were kept for a time in a forcing room in the conservatories, but were soon placed out-of-doors, after several of the plants had been attacked and killed by another fungus (*Botrytis*). About June 25th, several small, pink *Tubercularia*-like bodies appeared on two of the dead stems. These bore no conidia. Nothing has yet been produced on the living plants, nor, in the light of Mayr's experiments noted on a previous page, could results be expected in so short a time.

On the fifth of June, fresh conidia from Chautauqua county were innoculated on living currant bushes in the Horticultural grounds. An incision was made through the bark into the wood of young shoots, and portions of tubercles bearing conidia inserted. No results have yet been obtained from this experiment.

III. REMEDIES.

We have seen that the mycelium of the fungus, after having once gained entrance to the plant, lives from year to year in the tissues of the host; that it may remain there a long time without producing any external indications of its presence; and that in this way it may be transmitted through cuttings. The first suggestion, therefore, is that all cuttings be taken from plants known to be free from the disease. It is not safe to take cuttings from apparently healthy plants in a diseased patch, but they should be obtained from localities where the disease is not present. This is the more important, since the conidia (or summer spores) exist in the soil and on the bushes, so that cuttings are liable to infection through their cut surfaces, as Mayr has pointed out. The trouble being a deeply seated one, and the conidia liable to dispersion at various seasons of the year, spraying is not to be recommended. The conidia probably do not affect entrance to the plant through healthy parts, but through cut or injured surfaces. These should, therefore, be avoided as much as possible. The only positive remedy that can be suggested is the removal of the whole plant as soon as the disease begins to be manifested in the yellow foliage and prematurely colored fruits. The diseased plants should be burned, as the spores and conidia may be produced in abundance on dead plants and the trouble communicated to living bushes.

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